FIGURE 1

ADAPTIVE OUTPUT FEEDBACK CONTROL SYSTEM
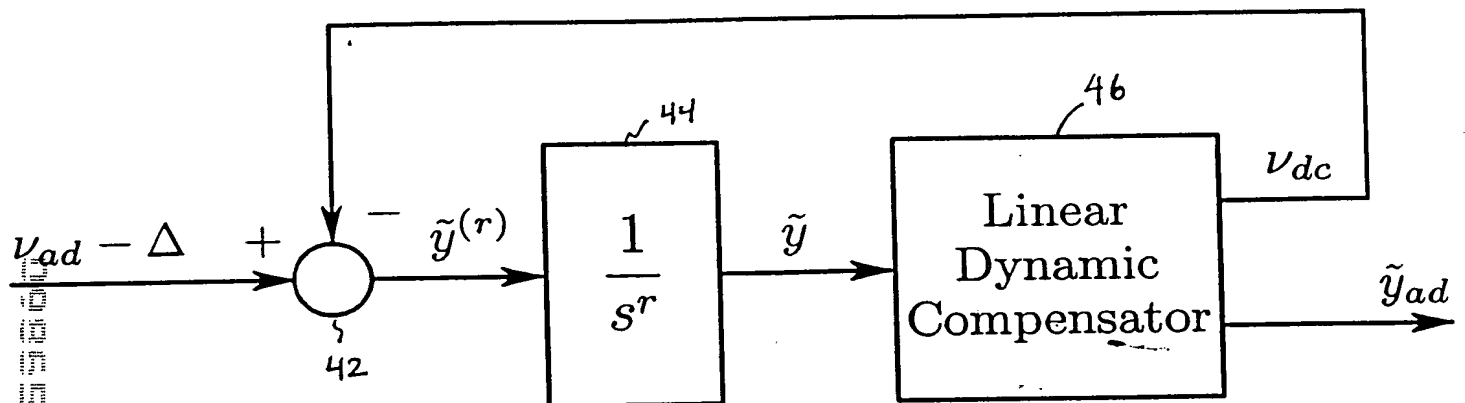
FIGURE 2
Tracking Error Signal Analysis

$$\nu_{ad} - \Delta \quad + \quad - \quad \tilde{y}^{(r)} \qquad \frac{1}{s^r} \quad \tilde{y} \qquad \text{Linear Dynamic Compensator} \qquad \nu_{dc} \qquad \tilde{y}_{ad}$$

42

44

46

FIGURE 3

LINEAR DYNAMIC COMPENSATOR (LDC)

ν_{dc}

$\dfrac{N_{dc}(s)}{D_{dc}(s)}$

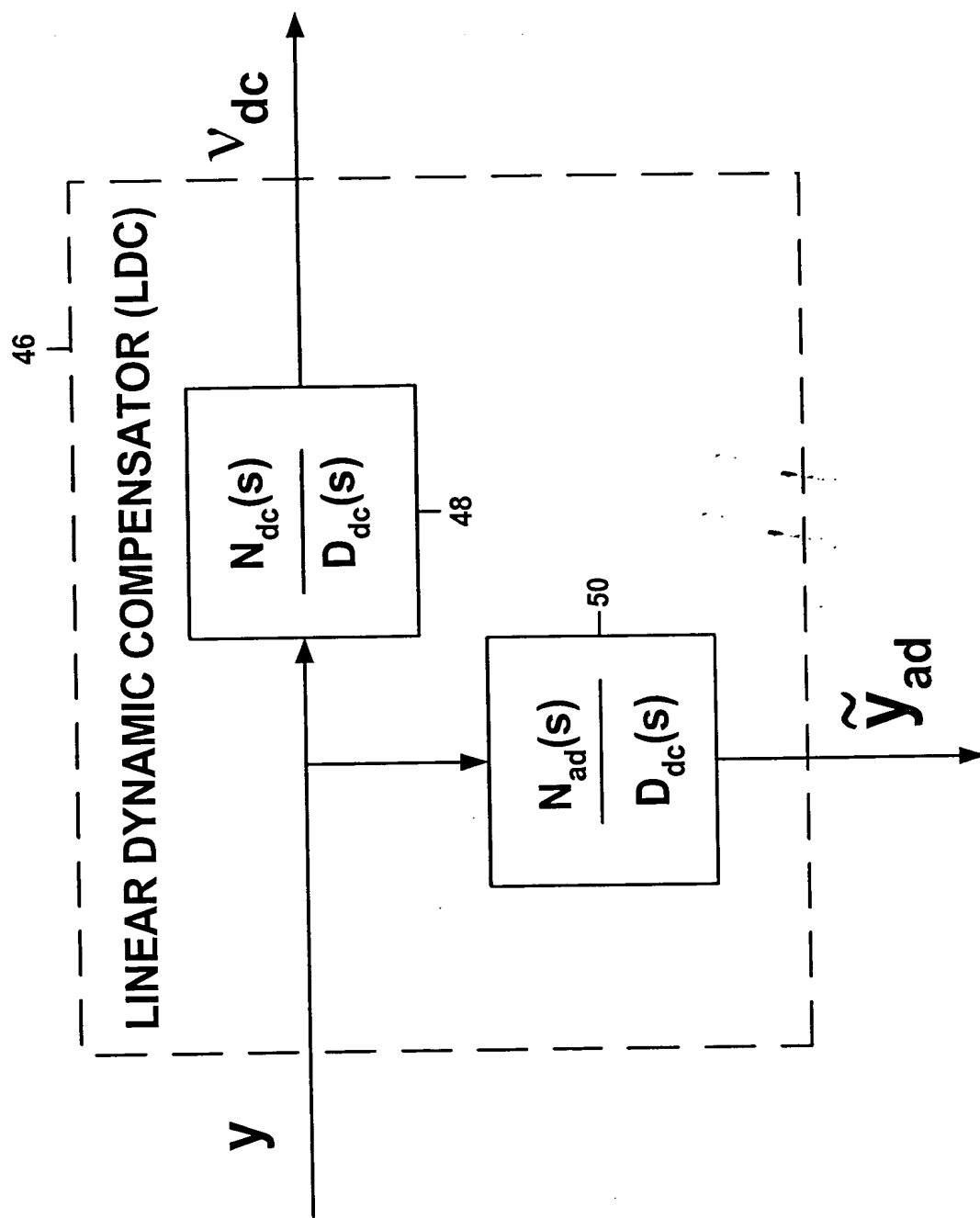$\dfrac{N_{ad}(s)}{D_{dc}(s)}$

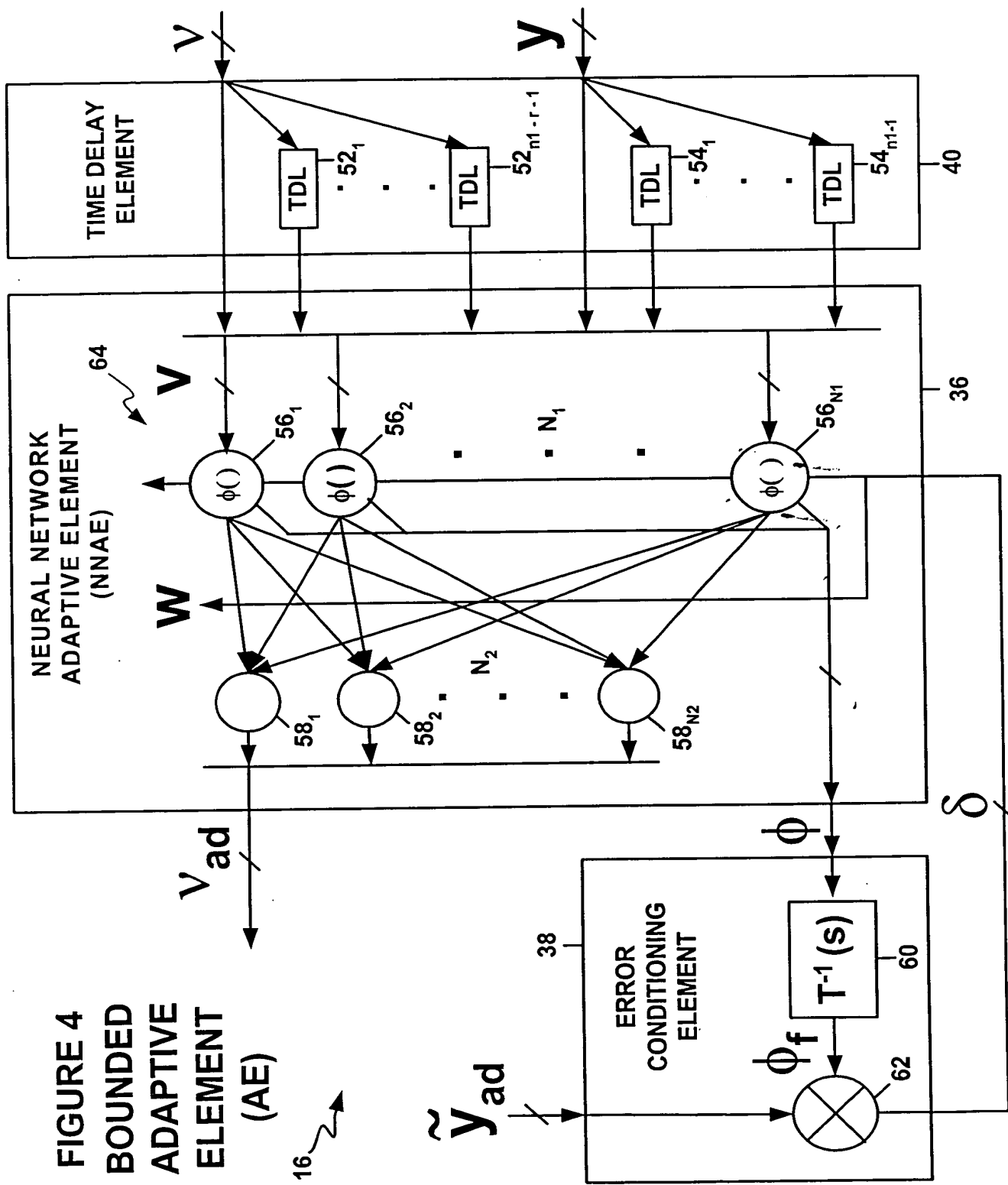$\tilde{y}_{ad}$

y

FIGURE 4
BOUNDED
ADAPTIVE
ELEMENT
(AE)

FIGURE 5

PROCESSOR-BASED ADAPTIVE CONTROL SYSTEM USING DIRECT OUTPUT FEEDBACK

FIGURE 6

S1 — (START)
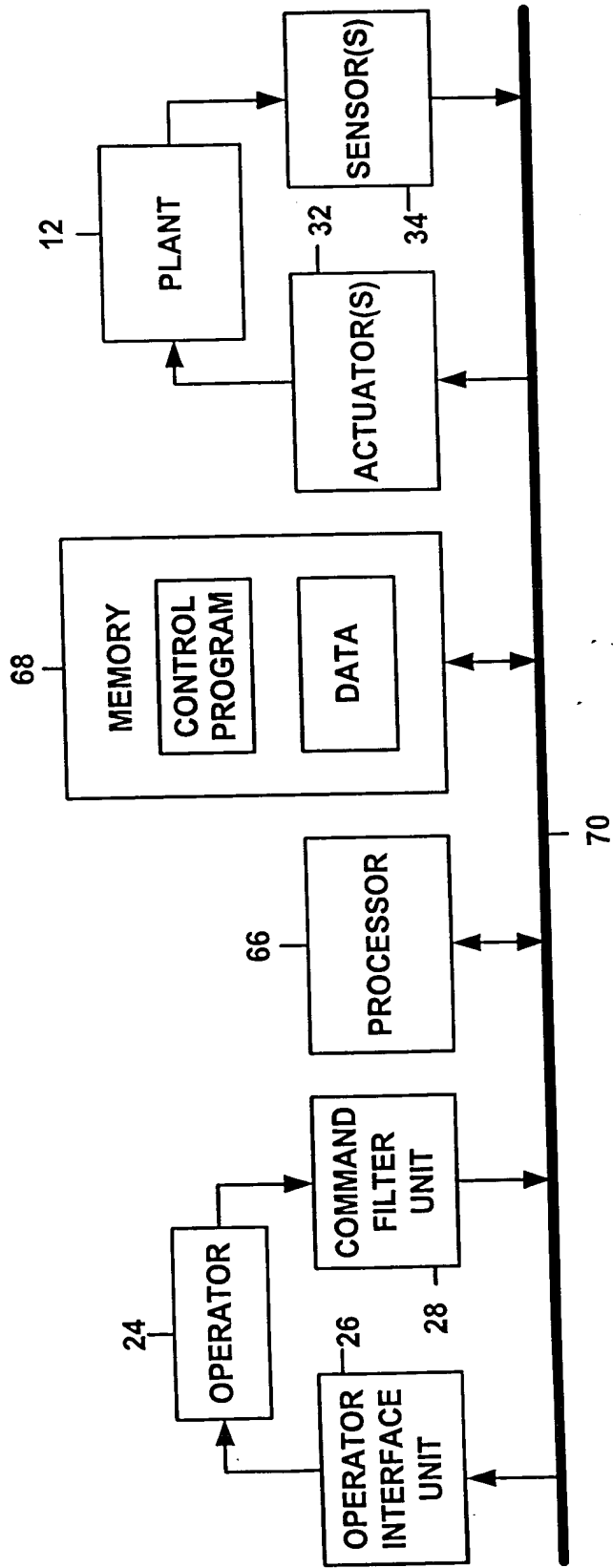
S2 — GENERATING COMMAND CONTROL SIGNAL δ_c BY INVERTING AN APPROXIMATE MODEL OF PLANT DYNAMICS, BASED ON PSEUDO-CONTROL SIGNAL ν AND PLANT OUTPUT SIGNAL y

S3 — SUPPLYING THE COMMAND CONTROL SIGNAL δ_c TO CONTROL THE PLANT

S4 — GENERATING A PLANT OUTPUT SIGNAL y

S5 — GENERATING A TRACKING ERROR SIGNAL $\tilde{y}$ BY DIFFERENCING CORRESPONDING SIGNAL COMPONENTS OF THE COMMANDED OUTPUT SIGNAL y_c AND OPTIONAL DERIVATIVES THEREOF, AND A PLANT OUTPUT SIGNAL $\tilde{y}$

S6 — GENERATING A PSEUDO-CONTROL COMPONENT SIGNAL ν_{dc} BASED ON THE TRACKING ERROR SIGNAL $\tilde{y}$

S7 — GENERATING A TRANSFORMED SIGNAL $\tilde{y}_{ad}$ BASED ON TRACKING ERROR SIGNAL $\tilde{y}$

S8 — GENERATING AN R-TH DERIVATIVE OF COMMANDED OUTPUT SIGNAL $y_c^{(r)}$.

S9 — GENERATING A SIGNAL $\tilde{y}_{ad}$ TO RENDER TRANSFER FUNCTION FROM ν_{ad} TO $\tilde{y}_{ad}$ TO BE STRICTLY POSITIVE REAL

S10 — GENERATING A TRAINING SIGNAL δ BY FILTERING BASIS FUNCTION(S) ϕ AND MULTIPLYING THE FILTERED BASIS FUNCTION(S) ϕ BY TRANSFORMED SIGNAL $\tilde{y}_{ad}$

S11 — UPDATING CONNECTION WEIGHTS W OF A NEURAL NETWORK IN A BOUNDED MANNER BASED ON THE TRAINING SIGNAL δ

S12 — GENERATING DELAYED VERSIONS OF PSEUDO-CONTROL SIGNAL ν

S13 — GENERATING DELAYED VERSIONS OF PLANT OUTPUT SIGNAL y

S14 — GENERATING THE ADAPTIVE CONTROL SIGNAL ν_{ad} BASED ON PSEUDO-CONTROL SIGNAL n AND DELAYED VALUES ν_d, PLANT OUTPUT SIGNAL y AND DELAYED VALUES y_d, AND CONNECTION WEIGHT(S) W, V AND BASIS FUNCTION(S) ϕ UPDATED BASED ON TRACKING ERROR SIGNAL δ

S15 — GENERATING A PSEUDO-CONTROL SIGNAL ν BASED ON r-TH TIME-DERIVATIVE OF COMMANDED OUTPUT SIGNAL $y_c^{(r)}$, PSEUDO-CONTROL COMPONENT SIGNAL ν_{dc}, AND ADAPTIVE CONTROL SIGNAL ν_{ad}
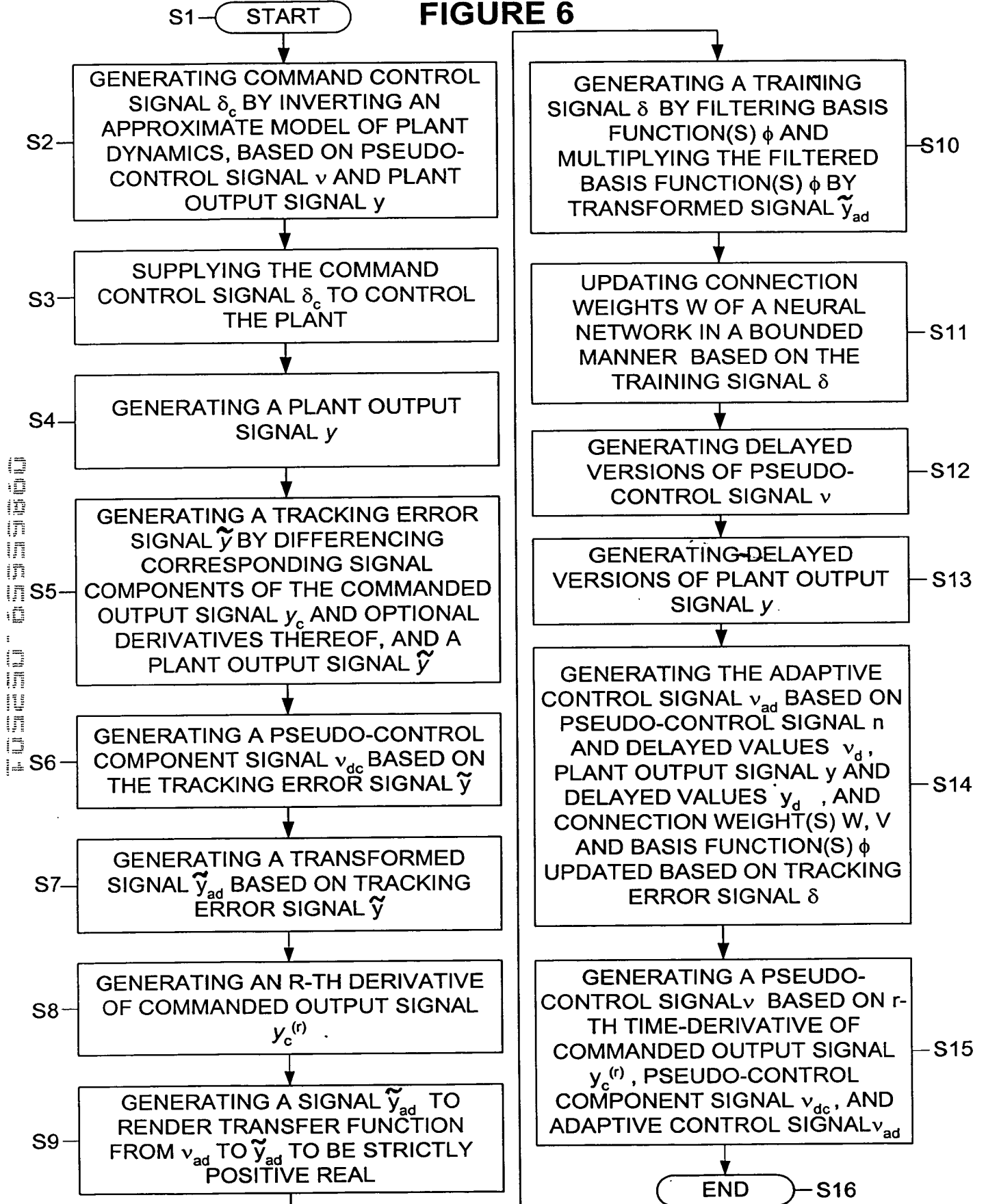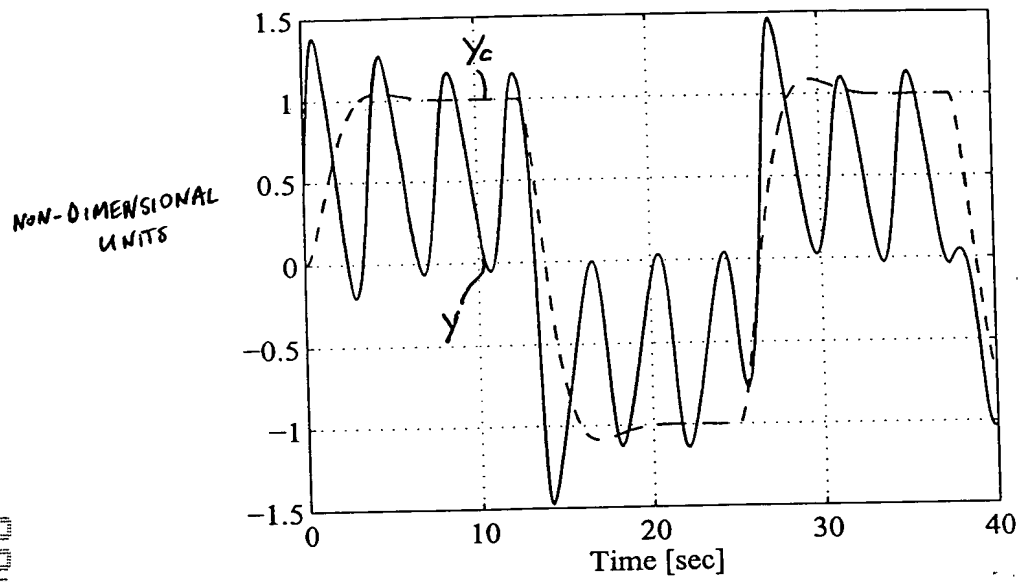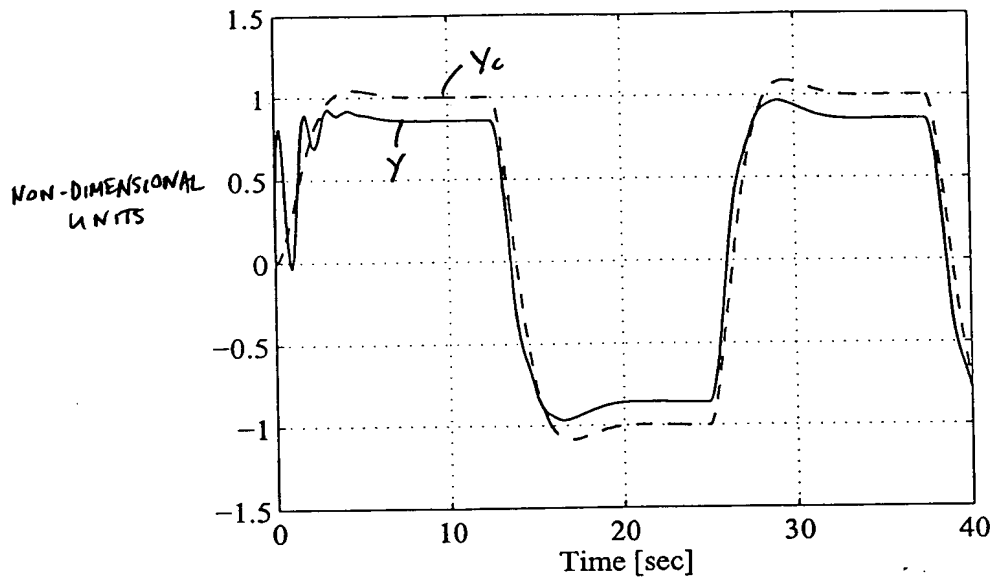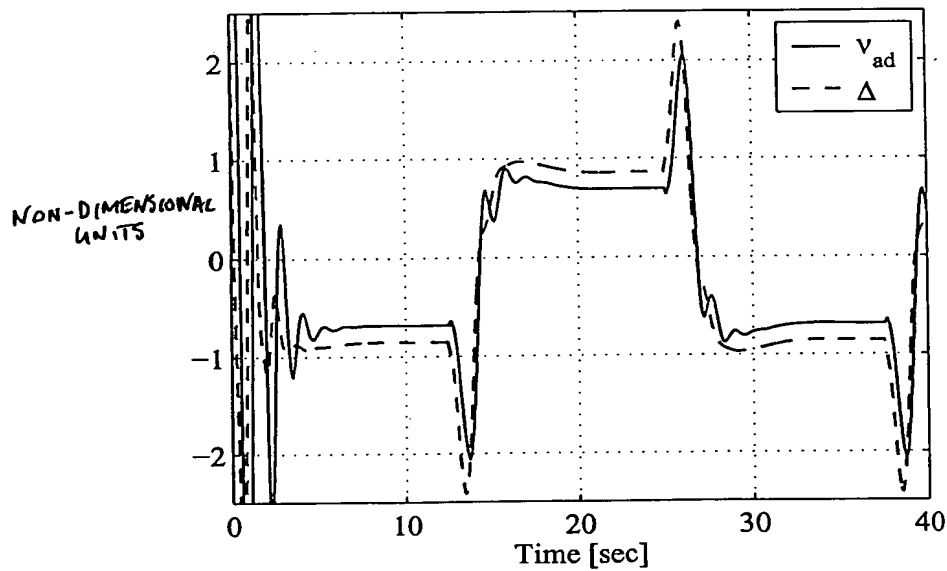
S16 — (END)

FIGURE 7

System without unmodelled dynamics: response with linear compensator
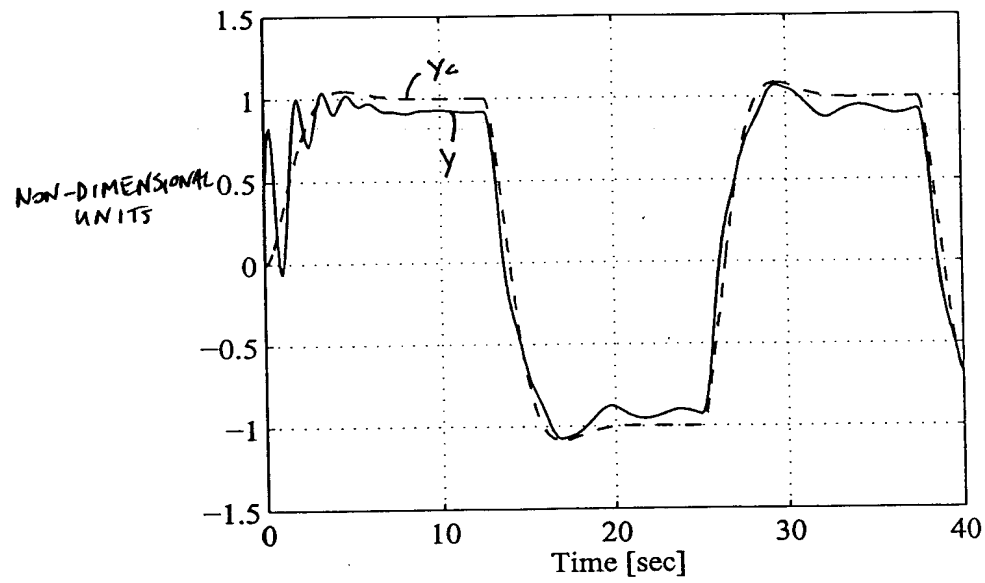
FIGURE 8A

(a) System tracking

FIGURE 8B

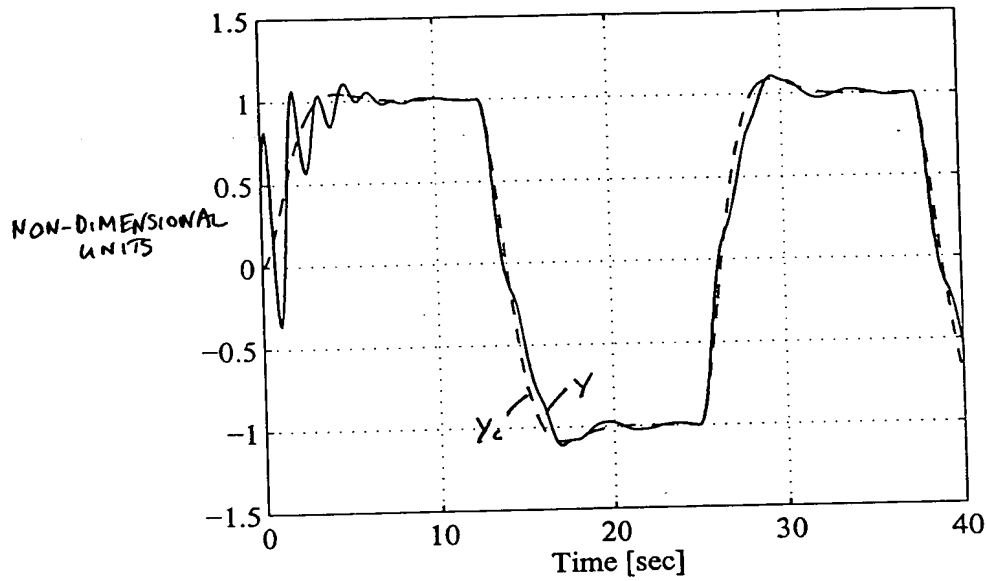(b) NN output ν_{ad} and inversion error Δ

System without unmodelled dynamics and NN controller
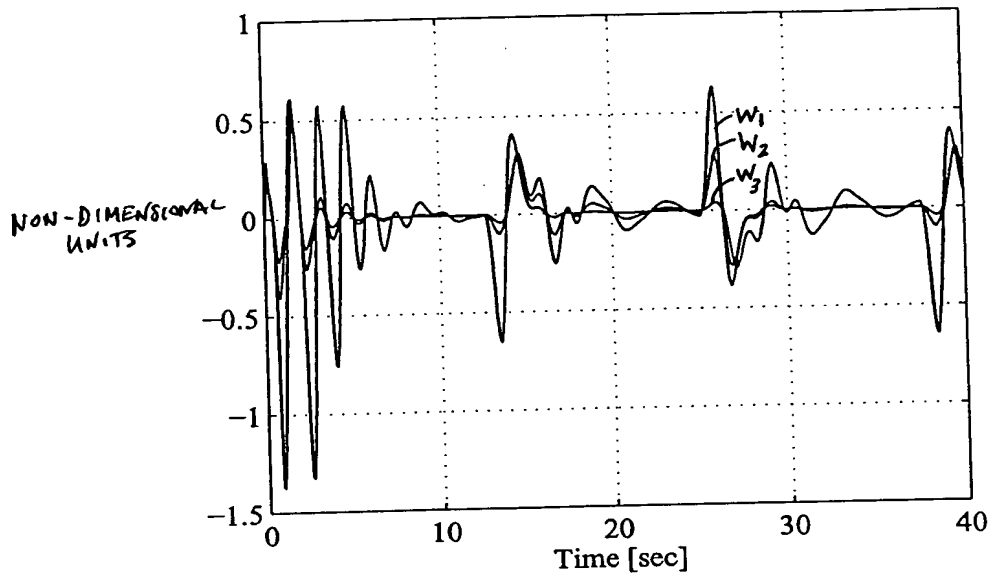
FIGURE 9

System with unmodelled dynamics: response with NN controller

FIGURE 10A

(a) System tracking

FIGURE 10B

(b) NN weight history

System with unmodelled dynamics: response with NN controller and linear

compensator